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The Cixiidae (Hemiptera: Fulgoromorpha) of the Mascarenes islands and Madagascar. Endemism and description of new taxa from Réunion with notes on their host plants

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Abstract. Two new species (Hemiptera, Fulgoromorpha, Cixiidae) included in a new genus, *Meenocixius* gen. n., and associated with *Acanthophœnix rubra* (Bory) H. Wendl. (Arecaceae) are described from the island of La Réunion: *M. bebourensis* sp. n. and *M. virescens* sp. n. This genus shows several autapomorphies in its tegmina venation, very particular within the Fulgoromorpha. *Borbonomyndus* gen. n., is proposed for another new species, *B. pandanicola* sp. n. associated with *Pandanus purpurascens* Thouars (Pandanaceae), and *B. pallidus* (Synave), previously described as a member of the genus *Eumyndus* Synave. According to morphological and ethological data, *E. bistriatus* is synonymized with *B. pallidus*, of which three different forms are recognized. All species of *Borbonomyndus* are found associated with *Pandanus*. These two new genera are endemic to La Réunion. Without taxonomic standing, the subspecies of *Brixia belouvensis* are synonymyzed and restricted to four different forms. A key is proposed for the Cixiidae of La Réunion, which now includes 12 species belonging to 6 different genera: *Achaemenes*, *Aselgeoides*, *Brixia*, *Oliarus* (but we show that the species placed in this genus need to be reviewed), *Borbonomyndus,* and *Meenocixius*. Monophyly of *Eumyndus*, from which *E. perinetensis* Synave is excluded, is substantiated. Following the new interpretation, this genus is now restricted to Madagascar. The species *Cubana insularis* Muir, from the island of Rodrigues, is transferred to a new genus: *Achaebana* gen. n. Finally, cixiid endemism and their host-plant associations in the Mascarenes are discussed.

INTRODUCTION

Almost all species of Cixiidae in the Mascarene islands are endemic and associated with native vegetation (Williams, 1975a; Attié et al., 1998) and particularly endemic plants (Attié, 1999). In Mauritius, the 35 species and subspecies belong to three genera (*Achaemenes* Stål, 1866, *Brixia* Stål, 1856 and *Oliarus* Stål, 1862) (Synave, 1960, 1961; Williams, 1975a, 1983; Williams & Williams, 1988) including 27 species in the genus *Brixia*, which appears to be the most diversified Mascarene genus (Williams & Williams, 1988). Rodrigues has the least diversified fauna of the three Mascarene islands of the archipelago with only four species belonging to two genera (*Brixia* and *Cubana* Uhler, 1895) (Muir, 1925; Williams, 1983; Williams & Williams, 1988). The data on the Cixiidae of Madagascar consists mainly of alpha-taxonomic information on more than 60 species belonging to 7 genera (Synave, 1956, 1965). Furthermore, etho-ecological information is scarce.

The Cixiidae of La Réunion were first studied by Synave (1965) and then by Williams (1975a, b). Their work distinguished ten different species (Williams & Williams, 1988; Bonfils et al., 1994) belonging to five genera (*Achaemenes*, *Aselgeoides*, *Brixia*, *Oliarus* and *Eumyndus* Synave, 1956). Very little etho-ecological data exists, particularly on their host-plants.

In order to analyse the endemism of this insular fauna, particularly in relation to their endemic host-plants, new collections and a taxonomic revision were undertaken, together with a comparison of the cixiid species of the different Mascarene islands and Madagascar. The field work added three new species of Cixiidae to the fauna of La Réunion, which are also described. The taxonomic revision gave us the opportunity to:

1. Redefine the genus *Eumyndus*, which is now restricted to Madagascar;
2. propose three new endemic genera: *Borbonomyndus* gen. n. and *Meenocixius* gen. n. from La Réunion, and *Achaebana* gen. n. from Rodrigues;
3. to provide new taxonomic information for two other genera present in La Réunion: *Oliarus* and *Brixia*. Some new etho-ecological data are provided for most of these taxa and the origin of cixiid endemism discussed.

THE *EUMYNDUS* GENUS FROM MADAGASCAR

In 1960, Synave described two cixiid species from Réunion which appeared to be morphologically intermediate between the genus *Eumyndus* from Madagascar and *Volcanalia* Distant, 1917, from Seychelles. However, these species were finally placed by Synave in the Malagasian genus *Eumyndus*.

A revision of these taxa, together with the description of a new species, allow us to transfer them to a new endemic genus *Borbonomyndus* gen. n. which also belongs to the Oecleini Muir, 1922. *Eumyndus* is therefore redefined and compared to a group of three closely related genera distributed in the same geographical area and that lack the transversal carina separating frons from vertex: *Volcanalia*, *Nesomyndus* Jacobi, 1917 and *Borbonomyndus* gen. n.

Eumyndus Synave, 1956

Type species. Eumyndus madagascariensis Synave, 1956: 180

Distribution. Endemic to Madagascar (Fig. 22)

Included species. *E. madagascariensis* Synave, 1956; *E. metcalfi* Synave, 1956; *E. kraussi* Synave, 1956, [excluded: *Eumyndus perinetensis* Synave, 1965]

The genus is redefined and characterized by the following combination of characters, some of them proposed as autapomorphies (A) for this taxa: Vertex without median carina, its posterior margin absolutely straight (A); posterior margin of the vertex almost twice as wide as anterior margin and wider than the compound eye narrowest diameter. Absence of the mediofrontal carina. Posterior margin of pronotum strongly concave, middle part (between the lateral carinae of the vertex) not visible in dorsal view as hidden under the head capsule. Lateral carinae of the pronotum reach the anteroventral margins in fronto-lateral view but turn dorsad before reaching the level of the compound eyes, then vanish dorsally. Tegminae with Sc+R separating before CuA. Epiproct short, anal tube posteroventrally extended in an impair process (A). Periandrium developed only on its left side and ventrally, with the lateral left process curved less or no more than 180°, pointing postero-ventrally. Aedeagus *s.s.* as a membranous tube situated on the right side.

Taxonomic note. The genus *Nesomyndus* differs from *Eumyndus* in having a median carina on the frons and the clypeus, and a narrow hollowed vertex, posteriorly angled and not masking the pronotum medially. The posterior margin of pronotum is strongly concave and still fully visible in dorsal view. In frontal view, a strong straight and oblique anterolateral carina runs orthogonally from the margin of the compound eye and reaches distally the anteroventral margin. *Volcanalia* is an endemic genus from the Seychelles, which differs from *Eumyndus* in having strong and wide mediofrontal carinae and in the shape of the thin hollowed vertex (as a furrow) between the compound eyes.

The Malagasian species *Eumyndus perinetensis* Synave, 1965, is clearly not congeneric with any of these taxa and has to be excluded from the genus *Eumyndus*. It differs by its frons bearing a delicate median carina and stronger and foliated lateral carinae, by the lateral carinae of the pronotum vanishing ventrally and not reaching the antero-ventral margin, and by the general conformation of the male genitalia, which bear two long processes on each side of the aedeagus. However, with *Eumyndus* it shares the wider posterior margin of the vertex and in dorsal view the strongly incurved posterior margin of the pronotum hidden medially by the head capsule. Probably a new genus should be created for this species, but this will have to be checked within a general revision of the cixiid fauna of Madagascar, which is out with the scope of this study.

The male genitalia of *E. metcalfi* differs from that of the type species, with the periandrium strongly developed ventrally and bearing a small spine-like process, a development absent in *E. madagascariensis*. The male of *E. kraussi* is still unknown.

With this new status *E. pallidus* becomes non congeneric with the other species and therefore a new genus is proposed.

DESCRIPTION OF NEW TAXA FROM LA RÉUNION ISLAND

Borbonomyndus gen.nov.

Type species. *Borbonomyndus pandanicola* **sp. n.**

Distribution. Endemic to La Réunion Island (Fig. 22)

Included species. *Borbonomyndus pallidus* (Synave, 1960), *Borbonomyndus pandanicola* **sp. n.**

Posterior margin of vertex angled, not straight, wider than anterior margin; its length less or just slightly longer than the short diameter of the compound eye; vertex not strongly hollowed but the lateral carinae elevated; no median carina. Frons without mediofrontal carina, lateral carinae in the same plane as the frontal disc, not pointing anteriorly but laterally. Clypeus without medioclypeal carina. Pronotum with posterior margin strongly concave, but still visible in dorsal view, not hidden by the head capsule; in frontal view, lateral pronotal carinae distally reach the anteroventral margins; more dorsally fully visible and S-curved around the eye margin, then vanishing dorsally. Mesonotum with three carinae, the lateral carina diverging posteriorly. Tegminae with Sc+R separating basally to CuA1 and CuA2. Epiproct long: As long or longer than the dorsal margin of the anal tube in lateral view. Anal tube posteriorly produced on each side of the epiproct forming two more or less developed processes. Lamina gonostyli present and short. Periandrium developed only on the left side and ventrally, forming a wide ring supporting the aedeagus in ventral view. Lateral left process of the periandrium long, thin, running postero-dorsad then turning ventrally and anteriorly at almost 360°. Aedeagus as a membranous tube situated on the right side.

Type species. *Borbonomyndus pandanicola* **sp. n.**

Taxonomic note. It is difficult to propose any synapomorphy for the genus moreover without any cladistic analysis. However, the very long lateral process of the periandrium, curved at 360° might represent a good autapomorphy for the genus. *Borbonomyndus* is close to *Eumyndus* by the general conformity of the male genitalia, but the autapomorphic shape of the vertex in the Madagascar genus allows a quick separation.

Borbonomyndus pallidus (Synave, 1960) comb. n.

Eumyndus pallidus Synave, 1960: 138
Eumyndus bistriatus Synave, 1960: 138, **syn. n.**

TABLE 1. Tegminal patterns of *Borbonomyndus pallidus* in relation to its distribution, host-plants and type of genitalia. Tegminal patterns: a: ♂-hyaline; b: ♂-bi-striped chesnut, b: ♂-bi-striped chesnut very pale; c: ♀-bi-striped dark chesnut; d: ♀-bicoloured; e: ♀-hyaline. Aedeagus type patterns: I: with 4 spines; II: with 3 spines.

Patterns	Genitalia types	Host plants	Localities	Dates	References
d		*P. montanus*	P. des Fougères (E)	14.III.1997	1400
a, c	II	*P. purpurascens*	P. des Fougères (E)	14.III.1997	1402
a, b, d		*P. purpurascens*	P. des Fougères (E)	14.III.1997	1403
a, b, c, d		*P. purpurascens*	P. des Fougères (E)	4.II.2000	1667
a, b, c, d	II, one apical spine feebly marked	*P. purpurascens*	S. Pointe du Tremblet	26.III.1997	1401
b, c		*P. purpurascens*	S. Pointe du Tremblet	26.III.1997	1404
b × c	II	*P. purpurascens*	S. Pointe du Tremblet	5.XII.1999	1662
b	II		S. Pointe du Tremblet		1663
a × c	II	*P. purpurascens*	S. Pointe du Tremblet	5.XII.1999	1664
a, c, e	II	*P. montanus*	P. des Palmistes	30.X.1997	1405
a, c, e		*P. montanus*	P. des Palmistes	30.X.1997	1406
a, c, d	I	*P. purpurascens*	Vallée-Heureuse	13.I.1998	1586
b	I		Vallée-Heureuse		1586
c		*P. purpurascens*	Mare-Longue	13.XI.1999	1660
b, d		*P. purpurascens*	Mare-Longue	13.XI.1999	1661
b × c		*P. purpurascens*	Mare-Longue	13.XI.1999	1665
a × c	I	*P. montanus*	Plaine des Chicots	7.I.2000	1666

In “Le Naturaliste malgache” dated 1959 but published in 1960 (2nd quarter), Synave described two species in the genus *Eumyndus*: *E. pallidus* with hyaline tegminae (Fig. 11) and *E. bistriatus* with bi-striped dark chestnut tegminae (Figs 2, 10). As no male was recorded for *E. bistriatus* and no female mentioned for *E. pallidus*, Synave added that it was possible that *E. bistriatus* may be a form of *E. pallidus*. According to Williams (1975b), these two species are indistinct and both belong to *E. pallidus*. Indeed, one of the two females collected by this author is bi-striped as is *E. bistriatus*, whereas the second had only a trace of pigmentation on the tegminae. Our new collects and field observation of numerous specimens with various tegminal patterns, allow us to present new details and, in agreement with Williams (1975b), to formally synonymyse these two species, and include them in the new genus *Borbonomyndus*.

Various tegminal patterns were observed (Figs 9–11). Only two of them occur in male specimens: a hyaline pattern (a) corresponding to the description of *E. pallidus* by Synave (1960) and a bi-striped chestnut pattern (b), of variable strength (Figs 1, 2). The (b) pattern is similar to the one reported by Synave (1960) for females of *E. bistriatus*. In females, three different patterns were observed: a bi-striped dark chestnut pattern (c) (Fig. 2), similar to *E. bistriatus*, a new bicoloured pattern (d) with the whole of the anterior prenodal part of the tegminae coloured (Figs 3, 9) and females with hyaline tegminae (e).

The study of the male genitalia of specimens with (a) and (b) tegminal patterns revealed similar structures (Fig.15), except for the genital spinulation. Two types of genitalia were observed: in type I there were four spines (Fig. 17) and in type II three, with one of the apical spines absent (Fig. 16). The genitalia of *E. pallidus* [form (a)] illustrated by Synave (1960: fig. 6) correspond to type I. Both genital types also occur in individuals with tegminal patterns (a) and (b) (Table 1).

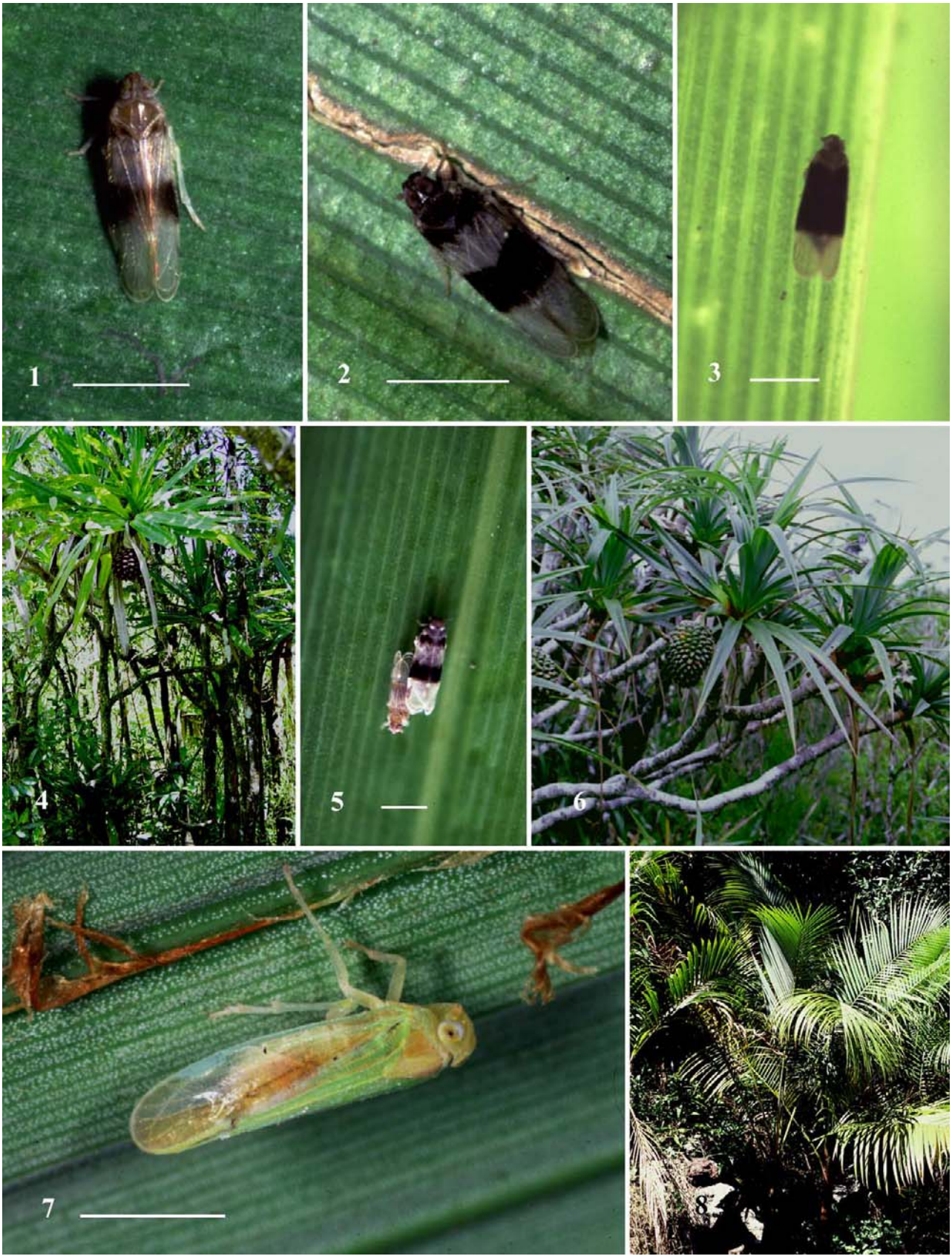
In addition, six couples were collected *in copula*. Only the most common of the tegminal patterns of were concerned: (a)x(c) and (b)x(c) (Fig. 5). Dissections showed that males of both genital types mated with females with the (c) pattern.

These observations led us to conclude that the two taxa are synonyms as supposed by Synave in 1960 and expected by Williams (1975b). There is, therefore, no reason to maintain *E. bistriatus* and *E. pallidus* as separate species. To facilitate future field researchs three forms are however recognized at the infraspecific level:

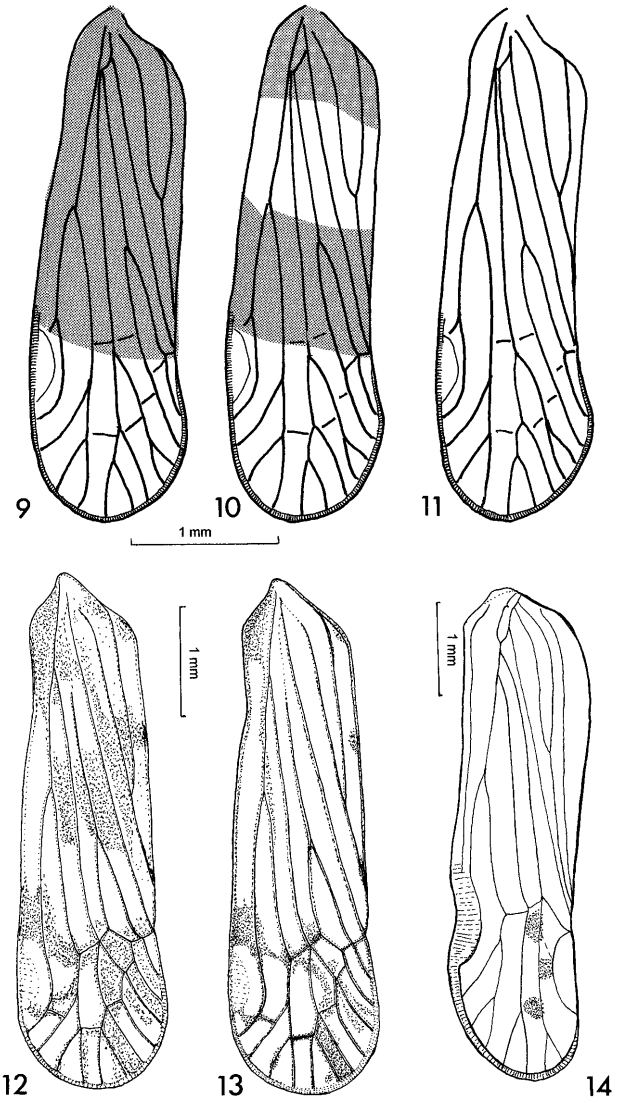
Borbonomyndus pallidus (Synave, 1960: 138)
Eumyndus bistriatus Synave, 1960: 138, **syn. n.**
form *pallidus*: Hyaline tegminae - males with pattern (a) or females with pattern (e) -
form *bistriatus*: Bi-striped tegminae - males with pattern (b) or females with pattern (c)
form *bicoloratus*: Bicoloured tegminae, known only from females with pattern (d).

The various and distinct phenotypic patterns shown by *B. pallidus* might be considered as a evidence of speciation in progress. This hypothesis still needs to be tested, but its determinism is probably not linked to host-plant speciation. Indeed, all forms of *E. pallidus* are always associated with only two endemic species of Pandanaceae on La Réunion: *Pandanus purpurascens* Thouars and *P. montanus* Bory (Table 1).

Another hypothesis is that the different patterns observed are the result of eco-geographical constraints. Indeed, *B. pallidus* is found in lowland forest (Mare-



Figs 1–8. 1 – Male of *Borbonomyndus pallidus*, bi-stiped chesnut tegminae; 2 – Female of *B. pallidus*, bi-stiped dark chesnut tegminae; 3 – Female of *B. pallidus*, bicoloured patterned tegminae; 4 – *Pandanus purpurascens*, a host plant of *B. pallidus* and *B. pandanicola*; 5 – *B. pallidus in copula*; 6 – *Pandanus montanus*, a host plant of *B. pallidus*; 7 – Female of *Meenocixius virescens*; 8 – *Acanthophœnix rubra* (Arecaceae), the host plant of *M. virescens* and *M. bebourensis*. (scale: 2 mm)



Figs 9–14. *Borbonomyndus pallidus* (Synave) right tegmina: 9 – form *bicoloratus*: new bicoloured tegmina pattern in a female; 10 – form *bistriatus*: bi-striped chestnut tegmina pattern in a female [= *E. bistriatus* sensu Synave (1960)]; 11 – form *pallidus*: hyaline tegmina pattern [= *E. pallidus* sensu Synave (1960)]; 12, 13 – *Borbonomyndus pandanicola* sp. n.; 14 – *Meenocixius bebourensis* sp. n.

Longue from 470 m altitude) up to mountain rain forest (1500 m altitude) (Attié, 1999). This area is highly diverse in various biotopes. However, the different patterns seem restricted to rather delimited geographic areas (Fig. 22): The (d) and (b) patterns were only observed in "Plaine des Fougères", in "Sentier de la pointe du Tremblet" and in "Mare-Longue", and the (e) pattern only in "Plaine des Palmistes". Patterns (a) and (c) occur in all areas. The same was so for the male genitalia types as only one type is observed in each area (Table 1). However, these observations do not necessarily support either hypothesis, and perhaps the observed tegminal pattern polymorphism is only the result of the expression of one or more alleles. A further study of the different populations of *E. pallidus* is now needed.

Material examined. 1♀ (d), Plaine des Fougères (Est), 14.III.1997, on *Pandanus montanus* Bory (Pandanaceae) (Ref. MA 1400, M. Attié rec.); 7♂ (a), 8♀ (c), *idem* on *P. purpurascens* Thouars (Ref. 1402, M. Attié rec.); 6♂ (a), 2♂ ((b) pigmentation not very marked), 5♀ (d), *idem* (Ref. MA 1403, M. Attié rec.); 3♂ (a), 2♂ (b), 4♀ (c), 4♀ (d), *idem*, 4.II.2000 (Ref. MA 1667, M. Attié rec.); 1♂ (a), 14♂ (b), 7♀ (c), 1♀ (d), Sentier de la pointe du Tremblet, 26.III.1997 on *P. purpurascens* (Ref. MA 1401, M. Attié rec.); 2♂ (b), 4♀ (c), *idem* (Ref. MA 1404, M. Attié rec.); 7♂ (a), 7♀ (c), 3♀ (e), Plaine des Palmistes, 30.X.1997, on *P. montanus* (Ref. MA 1405, M. Attié & G. Morel rec.); 7♂ (a), 9♀ (c) 2 of them are not very marked, 6♀ (e), *idem* (Ref. MA 1406, M. Attié & G. Morel rec.); 9♂ (a), 20♀ (c), 1♀ (d), Vallée-Heureuse, 13.I.1998, on *P. purpurascens* (Ref. MA 1586, Attié rec.); 19♀ (c), Mare-Longue (this locality is near Vallée-Heureuse), 13.XI.1999, on *P. purpurascens* (Ref. MA 1660, G. Morel rec.); 9♂ (b), 2♀ (d) *idem*, 5.XII.1999 (Ref. MA 1661, M. Attié rec.); 2 pairs *in copula* (b)x(c), *idem* (Ref. MA 1665, M. Attié rec.); 1 pair (b)x(c), Sentier de la Pointe du tremblet, 5.XII.1999, on *P. purpurascens* (Ref. MA 1662, Attié rec.); 1 pair *in copula* (b)x(c), *idem*, (Ref. MA 1663, Attié rec.); 1 pair *in copula* (a)x(c), *idem*, (Ref. MA 1664, Attié rec.); 1 pair *in copula* (b)x(c), *idem*, (Ref. MA 1665, Attié rec.); 1 pair *in copula* (a)x(c) sur *P. montanus*, plaine des Chicots, 7.I.2000, on *P. montanus* (Ref. 1666, M. Attié rec.).

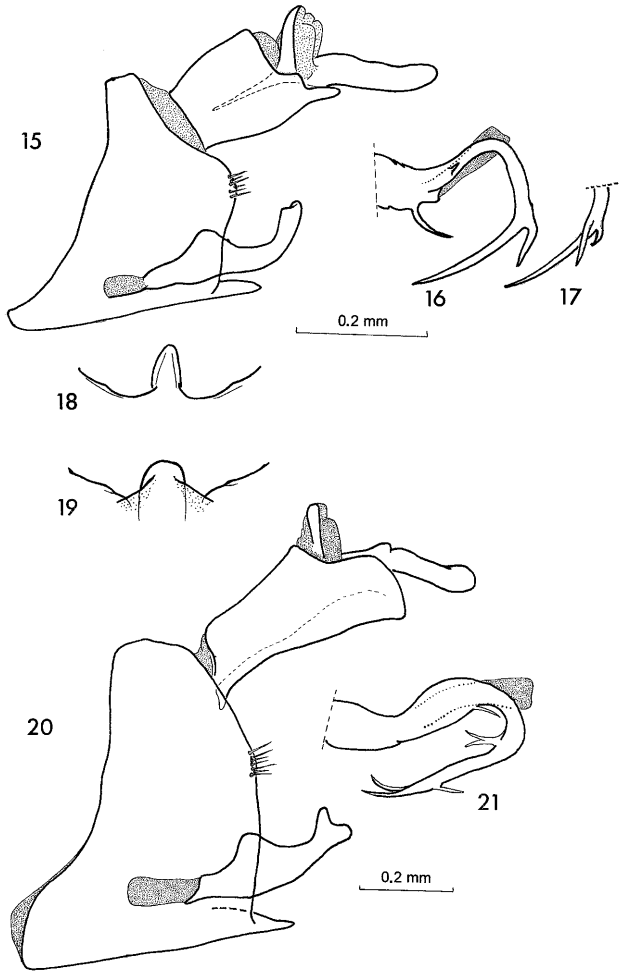
Borbonomyndus pandanicola sp. n.

General habitus pale brown with more or less darker and extended spots. Vertex pale brown, with two elongated darker spots on its median anterior part in darker specimens. Frons and clypeus dark brown with an elongated central creamish spot on the frons at the level of the eyes; carina generally paler. The area below the compound eye, around the ocellus and around the antennal base dark brown. Pronotum pale behind the lateral carina, dark anteriorly. Tegulae pale. Mesonotum uniformly pale brown in paler specimens, with two elongated dark bands between the lateral carinae and bordering the tegulae in the dark specimens. Tegminae with a large more or less extended brown spot: A basal costal one, an elongated one between Sc+R and M more or less elongated towards the posterior margin (absent in pale specimens), a band running on the nodal line extending more or less toward the cubital post-nodal area; second external median cell brown (Figs 12, 13).

Male genitalia. Anal tube relatively long, laterally produced into two flatened processes; in lateral view, epiproct as long as the dorsal margin of the anal tube (Fig. 20). Pygofer ventrally produced into a relatively wide rounded medioventral process (Fig. 19) while it is more slender and pointed in *B. pallidus* (Fig. 18); posterior margin regularly convex, produced into a rounded process medially. Left lateral process of the aedeagus apically with a pair of spines, a subdistal one pointing posteriorly; at mid length one spine pointing posteriorly followed by a double-spined process pointing anteriorly (Fig. 21). In lateral view, aedeagus s.s. reaching posteriorly as far as the lateral left process.

Measurements. Male (5 ex.), total length: 5.31–5.56 mm; tegminae: 4.37–4.69 mm.

Female (10 ex.), total length: 5.44–5.81 mm; tegminae: 4.44–4.94 mm.



Figs 15–21. *Borbonomyndus* sp., male genitalia - *B. pallidus* (Synave): 15 – pygofer, anal tube and gonostyli, lateral view; 16 – aedeagus, type II with only 3 spines; 17 – aedeagus, type I with 4 spines. 18 – medioventral process - *B. pandanicola* sp. n.: 19 – medioventral process; 20 – pygofer, anal tube and gonostyli, lateral view; 21 – aedeagus.

Distribution. La Réunion (Fig. 22).

Material examined. Holotype male: La Réunion, MA 1650, Mare-Longue, 13.XI.1999, on *Pandanus purpurascens* (G. Morel rec.), deposited in MNHN.

Paratypes in MNHN: 2♀ same data as holotype; 2♂, 4♀ La Réunion, MA 1653, Mare-Longue, 5.XII.1999, on *Pandanus purpurascens* (M. Attié rec.).

Other specimens. 2♂, 11♀, Mare-Longue, 13.XI.1999, on *P. purpurascens* (Ref. MA 1650, G. Morel rec.); 2♂, 6♀, Mare-Longue, 5.XII.1999 (Ref. MA 1653, M. Attié rec.); 8♂, 2♀, Plaine des Fougères, 4.II.2000 (Ref. MA 1668, M. Attié rec.) all in coll. Attié.

Taxonomic and distribution note. *B. pandanicola* is the largest species in the genus, and easily recognisable. It differs from *B. pallidus* in the general shape of the pygofer, a longer anal tube and the shape of the gonostyli (Figs 15, 20) as well as in the shape of the medioventral process of the pygofer (Figs 18, 19). Like *B. pallidus*, it also lives on *Pandanus purpurascens*. Its distribution however, seems much more restricted to the lowland rain forest of "Mare-Longue" (470–500 m altitude), and to the submontane rain forest of "Grand-Étang" (570 m) and "Plaine des Fougères" (800 to 950 m). Because *B. pallidus* seems to be a rather polymorphic species, we have selected *B. pandanicola* as the type species for the genus.

Meenocixius gen. n.

Type species. *Meenocixius bebourensis* sp. n.

Distribution. Endemic to La Réunion Island (Fig. 22)

Included species. *Meenocixius bebourensis* sp. n., *Meenocixius virescens* sp. n.

Vertex quadrangular, wider than long, margins strongly carinated, disk hollowed, median carina absent. Posterior margin obtusely angulate, lateral margins posteriorly regularly diverging, anterior margin straight. Frons with median carina not reaching the vertex; laterofrontal carinae foliated pointing laterad. Postclypeus with a median carina vanishing ventrally, lateral margins vanishing on the anteclypeus. Median ocellus almost absent. Pronotum with disk somewhat quandrangular, anteriorly straight, posteriorly concave and obtusely angulate; lateral carinae not reaching the posterior margin but strongly curved and parallel to posterior margin of the eye, running towards the middle of the lower pronotal margin without reaching it (Fig. 23). Mesonotum with lateral carinae slightly diverging, median carina vanishing posteriorly. Tegminae long, distinctive, with three long anal veins into the clavus, strongly elevated but not foliate; A1 and A2 fusing in the second third of the clavus, A1+A2 and A3 fusing at apex; basal part of A1 and A2 bearing setae regularly and horizontally spaced on each side of the vein; A3 cell (area posterior to A3) as wide as A2 cell (area posterior to A2) and wider than A1 cell (area between A1 and A2). Proximal part of costal margin convex. Sc+R+M+Cu basally fused in a common stem. Sc1 short, running into the node; Sc2 rounded, following the nodal margin. R tribranched, united to M by one nodal transverse r-m vein; M diverging at the nodal line in M1+2 and M3+4, preapically separating into four branches; Cu diverging at the nodal line, CuA1 fused with M3+4 over a short distance. R of the hindwing simple. Metacoxae lacking denticle. Metatibia without spines, apically with two groups of widely separated three spines. Metatibiotarsal formula 3–3/8–7/7; Metatarsus I as long as II + III together. Abdominal tergites VI, VII and VIII bearing on their posterior margin 12 finger-like invaginations corresponding to the canals of tegumentary glands (6 on each side), only visible after dissection.

Male genitalia (Figs 24–26): Pygofer symmetrical, bearing a long and lanceolated medio-ventral process, with a strong medio-ventral carina; latero-posterior margin of the pygofer developed dorsally forming a small wide-based triangular process; pygofer developed anteriorly on its ventral side. Gonostyli symmetrical, apically abruptly bent, turning transversally. Periandrium strongly developed with two long acute processes on its right side; the lateral one curved at 360°. Aedeagus tubular, apically wider than basally. Ventral support of the connective strong, anteriorly bent at mid length. Anal segment elongated, symmetrical, surpassing the genitalia in lateral

Fig. 22. La Réunion Island, collecting localities.

view; ventral margin dinstinctly longer than the dorsal one. (Fig. 26).

Female genitalia of orthopteroid type (Bourgoin, 1993) with a long and well developed ovipositor. No wax plate. Spermatheca very long, coiled 4–5 times from outside to inside in the same plane but not around itself. Bursa copulatrix bubble-like, totally covered with small tegumentary sculpturations. Ovipositor about 1.5 mm, longer than the anal tube. Gonapophyses IX fully united. Anal tube short. Epiproct strongly developed.

Type species. *Meenocixius bebourensis* sp. n.

Meenocixius bebourensis sp. n.

Very similar to *M. virescens* but general colour more orange. All lines and carinae tinged with orange. Tegminae without transverse veins; with three dark brown spots (Fig. 14), on m-cu, m1+2-m3+4 and m3+4-cu, respectively; in one specimen more or less coalescent. Apical spines of tibiae, tarsae and claws blackened at their tips. Ventral side of the abdomen dark brown.

Male genitalia with periandrium ring-like, prolonged by a ventral spine bent upwards and slightly to the right. Lateral to the aedeagus, periandrium with a long spine bent laterad at 360°, sometimes passing below the aedeagus by slightly turning to the left. Gonostyli symmetrical, medially inflated, apically transverse and bilobate (Fig. 24), the internal lobe slightly longer than the lateral one. Anal tube long, its ventral margin in lateral view more than twice as long as the dorsal margin. Epiproct not reaching the posterior margin of the anal tube (Fig. 27).

Measurements. Male (2 ex.), total length: 5.72 and 5.88 mm, tegminae: 4.8–5.2 mm;

Female (1 ex.), total length: 6.35 mm, tegmina: 5.65 mm.

Holotype male: La Réunion, MA 1412, Bébour, 10.XII.1996, on *Acanthophœnix rubra* palms, (M. Attié rec.), deposited in MNHN.

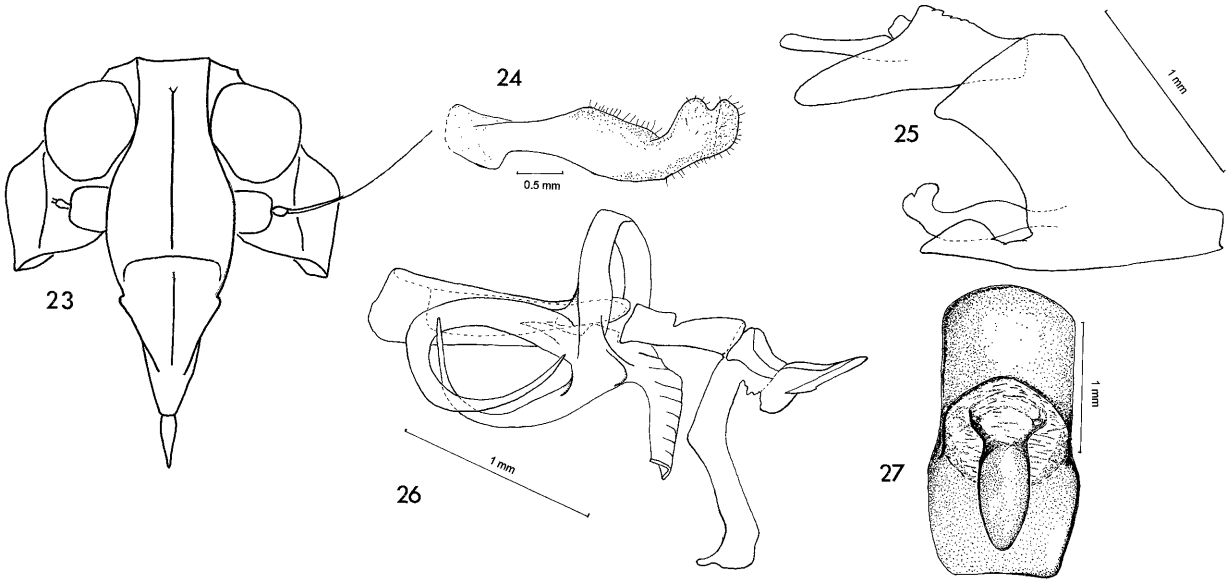
Paratypes. 1♀ same data as holotype (deposited in MNHN).

Other material examined. In MNHN: 1♂, 1♀, La Réunion, MA 1656, Sentier de la pointe du Tremblet, I.2000, (M. Attié leg.); in coll. Attié: 1♂, Bébour, 10.XII.1996, on *Acanthophœnix rubra*, (Ref. MA 1452, M. Attié rec.), 3♂, *idem*, (Ref. MA 1452, M. Attié rec.) in coll. Bonfils; 5 specimens sur *Acanthphoenix rubra*, Vallée-Heureuse, 23.XI.2000 (Ref. MA 1670, Attié rec. used for molecular sequencing).

Meenocixius virescens sp. n. (Fig. 28)

Smaller than *M. bebourensis*. General colour greenish to yellowish. Pronotum and disk of mesonotum paler. Lateral part of mesonotum somewhat more orange. All carinae concolorous or paler. Tegminae hyaline greenish, with transverse veins. No dark spot on the tegminae. Apical spines of tibiae, tarsae and claws blackened apically.

Male genitalia very similar to that of *M. bebourensis*, but smaller (Figs 25, 26). Periandrium ring-like, prolonged by a ventral spine bent upwards and slightly to the right. Periandrium lateral to the aedeagus on the right side, with a long spine bent at almost 360°. Gonostyli inflated medially, apically transverse and bilobate. Anal



Figs 23–27. *Meenocixius* gen. n. - *M. bebourensis* sp. n.: 23 – head capsule, frontal view; 24 – left gonostylus, latero-external view; 27 – anal tube, dorsal view. *M. virescens* sp. n.: 25 – pygofer, anal tube and gonostyli; 26 – male genitalia, dissected, view from right.

tube long, its ventral margin more than twice as long as the dorsal margin in lateral view. Epiproct long, surpassing the posterior margin of the anal tube.

Measurements.

Male (5 ex.), total length: 4.5–4.86 mm; tegminae: 3.96–4.25 mm.

Female (5 ex.), total length: 4.8–5.1 mm; tegminae: 4.25–4.45 mm.

Material examined.

Holotype male: Sur *Acanthophenix rubra*, Basse-Vallée, 3.IV.1999 (Ref. MA 1585, M. Attié rec.); deposited in MNHN.

Paratypes 10♂, 8♀ same data as holotype; deposited in MNHN.

Other material studied. 5♂, 5♀, La Réunion, MA 1539, Basse-Vallée, 4.XII.1997, on palmes of *Acanthophœnix rubra* (M. Attié & G. Morel rec.); 26♂, 23♀, *idem*, 4.XII.1997, (Ref. MA 1535, M. Attié & G. Morel rec.); 2♂, 5♀, *idem*, 13.I.1998 (Ref. MA 1583, M. Attié rec.); 14♂, 10♀, *idem*, (ref. MA 1585, Attié rec.); 5♂, 6♀, *idem*, 19.V.1998 (Ref. MA 1669, M. Attié rec.); 1♂, 1♀ *in copula*, *idem*, 10.IV.1999 (Ref. MA 1586, M. Attié rec.) in coll. Attié.

Notes about *Meenocixius*

Morphology. In the genus description, we refer to three anal veins. It is clear, however, that one of these veins - probably the first one - is not a real vein, homologous with a true anal vein. More morphological work is needed to verify this point, which might be important in future research, as the level of fusion of the anal veins may be a character of phylogenetic value

Taxonomy. *M. virescens* looks rather similar to *M. bebourensis* but is distinctly smaller, the general colour is paller and it lacks dark spots on the tegminae. The male genitalia are very similar but also much smaller, and the lateral processes of the periandrium are slender and generally transversally bent. As *M. virescens* lives at lower altitudes and in different habitats to *M. bebourensis* - but on the same host-plant - we describe them as different species. However, when more data becomes available they may be shown to be conspecific.

These two species look very different from other Cixiidae. Because of their very special venation bearing setae, the genus does not fit into the Cixiid classification proposed by Emeljanov (1997). According to his "tentative cladogramme", *Meenocixius* has a short displacement of the cubital transverse vein joining the wing margin and steeply tectiform forewings. Assuming that Emeljanov's classification is correct, these characters place *Meenocixius* close to the clade (((Brixidiini+Bennini)+Brixini)-+Andini) and could constitute a new tribe. However a complete cladistic analysis will be necessary to verify this statement.

Host-plants and distribution of *Meenocixius* on La Réunion. The adults of *Meenocixius bebourensis* sp. n. and *Meenocixius virescens* sp. n. live and reproduce on the lower surface of the palms of the red cabbage tree, *Acanthophœnix rubra* (Bory) H. Wendl. This species of Arecaceae (= Palmaceae) is endemic to La Réunion and Mauritius (Moore & Guého, 1984) and is not very common in natural biotopes. Wild trees are confined to humid forests from low to middle altitudes and have been overexploited for a long time. *Meenocixius* are to be found in the concave base of the leaflets and also close to the feathery line along the main vein of the palms.

Meenocixius bebourensis was only found in the montane rain forest (between 940 to 1350 m altitude), which receives an annual rainfall of 4000 to 5000 mm (Fig. 22). *Meenocixius virescens* has also been observed on wild cabbage trees and on cultivated seedlings in secondary forest or near the edge of native forest. This species is relatively more common in the region of "Saint-Philippe" (south-east of the island) at altitudes from 50 to 550 m.

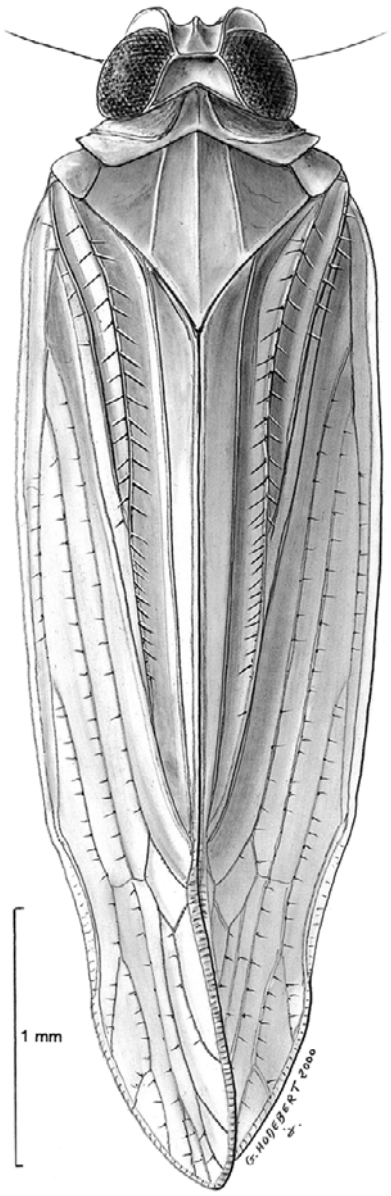


Fig. 28. *Meenocixius virescens* sp. n.

This area receives an annual rainfall of 3000 to 4000 mm, depending altitude (Soler, 1997).

THE GENUS *OLIARUS* IN LA RÉUNION

The genus *Oliarus* was erected by Stål (1862) for some species previously described in the genus *Cixius* Latreille. The type species was designated by Distant (1906) and it is an Oriental species described as *Cixius walkeri* Stål. Since, almost all cixiids bearing five keels on the mesonotum were included in this genus - 492 species according to Tsaur et al., 1988 - until the work of Emeljanov (1971), who begun to divide the composite genus *Oliarus* into different genera within a new tribe: Pentastirini Emeljanov, 1971. In 1987, Van Stalle published a review of the African fauna and listed 133 different species belonging to *Oliarus*. However, Emeljanov (1992) reassigned all of these species to three other genera *Eumecurus* Emeljanov, 1971, *Atonurus* Emeljanov, 1992 and *Suriola* Emeljanov, 1992. Therefore the genus *Oliarus* sensu Emeljanov, was considered as absent from continental Africa, and restricted to the Eastern Palaearctic, Oriental, Australian and Oceanic regions. Similarly, the Oriental species revised by Van Stalle in 1991, were also assigned to several new genera by Emeljanov 2002. The distribution of the genus *Oliarus* s.s. is therefore now restricted to the Oriental area (Indo-Malayan).

In La Réunion, however, two species have been described belonging this genus: *O. sanctiphilippi* Synave, 1960 and *O. borbonicus* Williams, 1975. Based on the new characters used by both Emeljanov (1971, 1992) and Van Stalle (1986, 1987) the two species are congeneric and share several key characters: vertex converging anteriorly in an acute angle; supraocular field narrower than anteocular field; postclypeus reaching the level of upper margin of antennae; clypeus mediocarinated; fork of median carina of frons extending approximatively 1/4 of the length of the frons; costal vein setiferous, but without granules; metatibia with two close spines basally (the first often very reduced) and two more developed spines on the first 2/3 of the tibia; metatibiotarsal formula: 1+2+3/7/5; subapical setae absent on apical teeth of segments of the hind tibia. Anal segment of female large, almost as wide as the wax plate, diamond-shaped. Male genitalia symmetrical, relatively simple with an elongate periandrium without a basal process, and two long spines apically.

Using the key for African species, these characters lead to the subtribe Oliarina Emeljanov, 1971, and to the couplet 6–7 in Emeljanov's key (1971). It differs from *Eumecurus* in its metatibiotarsal formula (6/7/5 versus 6/7/7 in *Eumecurus*), the absence of the asymmetrical projection of the anal tube, the clypeus reaching the upper level of antennae and having a short ovipositor (length not surpassing the length of the wax plate). It differs from *Pseudolarius* in the short fork in the mediofrontal carina and the presence of the distal segment of the aedeagus. Van Stalle (1987) also noted that the fauna of Madagascar and adjacent areas lack species of Pentastirine in common with the African continent. Indeed, these two species differ both from species of *Atonurus* and *Suriola* in having a symmetrical pygofer with blunt lobes and by the rather simple condition of the male genitalia with an elongate tube-like periandrium without any basal supernumerary process (see Williams, 1975b, figs 1 and 2). According to Van Stalle (1986) the diamond-shaped female anal segment is characteristic of the genus *Peartolus* Van Stalle, 1986 and of the "*Oliarus lacon* group", (now *Suriola*, Emeljanov, 1992). However again, the male genitalia and the greater development of the female anal segment exclude these species from these two taxa.

Following Van Stalle's key (1991) to Oriental pentastirini, these characters lead to *Oliarus*, couplet III, and using Emeljanov's key (2002), the gonostyli with an apical laterodorsal tooth lead to the genus *Indolipa* Emel-

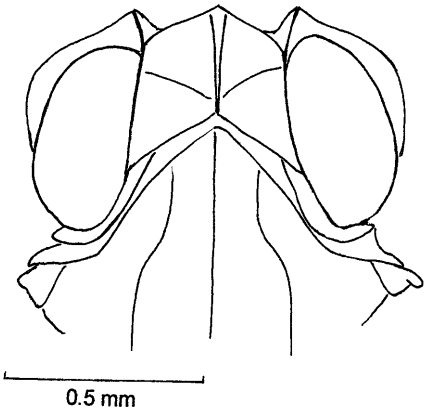


Fig. 29. *Achaebana insularis* (Muir, 1924) - head capsule, frontal view.

janov, 2002, a genus found in India and Malaysia. However, a more comprehensive study of the other *Oliarus* species described from Madagascaris needed before placing these species into this genus.

THE GENUS *BRIXIA* IN LA RÉUNION

According to Williams (1975b), intraspecific variation within the Reunion species *B. belouvensis* has no equivalent in Mauritius and could be considered as evidence of speciation in progress. But subspecies are local populations of a species inhabiting a geographic subdivision of the rang of a species. In describing subspecies, a geographic factor is therefore needed. However, the different subspecies described for *Brixia belouvensis* are only distinguished by the pigmentation of their tegmina (Williams & Williams, 1988) and lack any geographic criteria. Without taxonomic standing, the synonymy of the four subspecies is therefore proposed and as in *B. pallidus*, forms are only recognized here to facilitate field research.

Brixia belouvensis Synave, 1960 (1959: 142)
B. belouvensis aurata Synave, 1959: 145, **syn. n.**
B. belouvensis bipunctata Synave, 1959: 143, **syn. n.**
B. belouvensis tristis Williams, 1975: 678, **syn. n.**

form *belouvensis*
form *aurata*
form *bipunctata*
form *tristis*

KEY TO THE GENERA AND SPECIES OF CIXIIDAE FROM LA RÉUNION

A new key to genera and species of Cixiidae from La Réunion is provided, modified from the previous key of Williams (1975).

1. Cavernicolous species . . . . . *Brixia* sp. n. (Hoch et al., in prep.)
– Epigeic species 2
2 Mesonotum with 5 carinae . . . . . *Oliarus* Stål, 1862, 3
– Mesonotum with 3 carinae 4
3 In male, gonostyli apically quadrangular, ventrolateral margins of anal tube apically joined, tegminae with apical infuscation . . . . . *O. sanctiphilippi* Synave, 1960
– In male, gonostyli rounded dorso-apically, ventrolateral margins of anal tube apically clearly separated, tegminae hyaline . . . . . *O. borbonicus* Williams, 1975
4 Postclypeus without median carina . . . . . *Borbonomyndus* gen. n. 5
– Postclypeus with a median carina 6
5 Frons uniform brown; small species: less than 4.8 mm . . . . . *B. pallidus* (Synave, 1960)
– Frons dark brown, a pale spot between the eyes; large species, more than 5.2 mm . . . . . *B. pandanicola* sp. n.
6 Vertex in lateral view almost as long as the diameter of the compound eye . . . . . *Alsegeoides paludaris* Williams, 1975
– Vertex in lateral view no more as half long as the diameter of the compound eye 7
7 Tegminae with Sc, R and M with a common stem 8
– Tegminae with M separate basally from Sc + R . . . . . *Achaemenes quinquespinosus* Synave, 1960
8 Frons with a median carina . . . . . *Meenocixius* gen. n., 9
– Frons without a median carina . . . . . *Brixia* Stål, 1856, 10
9 Tegminae with three darks spots sometimes merging into each other . . . . . *M. bebourensis* sp. n.
– Tegminae greenish uniform, no dark spot . . . . . *M. virescens* sp. n.
10 Apical dorsal process of the gonostyli in lateral view with diverging margins 11
Apical dorsal process of the gonostyli with parallel or converging sides 12
11 Apical dorsal process of gonostyli longer than wide . . . . . *B. insularis* Synave, 1960
– Apical dorsal process of gonostyli as wide as long . . . . . *B. lalouetti* Synave, 1960
12 Apical dorsal process of gonostyli longer than wide in lateral view, with parallel margins . . . . . *B. belouvensis* Synave, 1960
– Apical dorsal process of gonostyli wider than height in lateral view, with converging margins . . . . . *B. costalis* Synave, 1960

RODRIGUES: THE *CUBANA* PROBLEM

The genus *Cubana* is almost exclusively confined to the Carribbean Islands and the presence of this West Indies genus in the Mascarenes area was questionable. Moreover, the species *C. insularis* Muir, 1925, was collected only once (a male) and only provisionally placed into this genus (Muir, 1925).

As expected by the venation of the tegmina only superficially similar to *Cubana*, a reexamination of this specimen, stored in the BMNH, revealed that it is not congeneric with *Cubana*, but is much closer to *Achaemenes*. Moreover, the very distinctive shape of the vertex, with an incomplete transverse ridge, angularly shaped oposite the anterior margin of the vertex, argue for placing this taxon in a distinctive taxonomic unit, perhaps endemic to Rodrigues. However a taxonomic revision and a phylogenetic analysis of the *Achaemenes* species of the area is needed to confirm the new genus proposed here.

Achaebana gen. n.

Type species. *Cubana insularis* Muir, 1924
Distribution. Endemic to Rodrigues Island
Included species. *Achaebana insularis* (Muir, 1924)

Vertex hexagonal (Fig. 29), its width medially equals its length anteriorally; disk hollowed, a middle carina not

reaching the posterior margin. Anterior and posterior margins parallel, the posterior one slightly elevated. Tranverse carina incomplete, vanishing, almost reaching the middle carina, not straight but angularly shaped oposite the anterior margin. Frons, postclypeus and clypeus medially carinated. Median ocellus absent. Frons at the antennal level almost twice as large as dorsally. Clypeofrontal margin dorsally arched. Lateral ocelli large, widely separated from the eyes; antennal base facing anterodorsally; pedicellus as long as wide, in frontal view almost hidden by the wide development of the laterofrontal foliated carinae at this level. Pronotum with disk almost hidden by the head capsule; posterior margin strongly angled anteriad, lateral margins rounded, meeting the posterior margin behind the eyes, then turning anteriad but not reaching the antero-ventral margin. Mesonotum tri-carinated, with lateral carinae slightly diverging in their anterior section, then widely diverging before converging posteriorly. Tegminae with M starting from the basal cell, five branches, M3+4 diverging at the postnodal line; Sc+R forking before the level of fork of CuA. Metatibiotarsal formula: 6/8/5.

The unique holotype male deposited in BMNH has not been dissected.

Unfortunately as already mentioned by Muir in 1925, the native vegetation of Rodrigues island has been "destroyed to a terrible extent" and the chance of collecting this species again is very low as it is probably extinct.

ENDEMISM AT THE GENERIC AND SPECIFIC LEVELS OF CIXIIDAE IN THE MASCARENES AND MADAGASCAR

The Cixiidae of La Réunion currently consist of 13 species (one species under description, Hoch et al., in preparation) belonging to six genera: *Achaemenes*, *Brixia*, *Oliarus*, *Aselgeoides*, *Borbonomyndus* and *Meenocixius*. Although the inventory of planthoppers of the Mascarenes, and particularly of Madagascar, still remains to be supplemented, we can state *a priori* that the generic diversity of Cixiidae is greater on La Réunion than Mauritius (*Achaemenes*, *Brixia* and *Oliarus*) and Rodrigues (*Brixia* and *Achaebana*). One explanation is that the genera found on these volcanic islands probably originated from Malagasy species. Seven Cixiid genera have been reported from Madagascar (Synave, 1956, 1965): *Achaemenes*, *Oliarus*, *Brixia*, *Aselgeoides* plus three Malagasy endemics: *Eumyndus*, *Nesomyndus* and *Typhlobrixia* Synave, 1952. The higher generic diversity of Cixiidae on La Réunion could be explained by its closer proximity to the large island. Indeed, La Réunion is about 700 km from Madagascar while Mauritius and Rodrigues are respectively more than 850 km and 1250 km from Madagascar. However such a comparison needs to be balanced by comparing the Mascarenes and Madagascar faunas more generally. Furthermore, endemism and species diversity should be taken into account.

Table 2 shows a basic common stock of three genera: the African genus *Achaemenes*, the Malagasian *Brixia*, and the genus *Oliarus*, absent from continental Africa but reported from Mascarenes and Madagascar and whose species probably belongs to a new generic taxa. In addition, the genus *Aselgeoides*, absent from Mauritius and Rodrigues, also probably belongs to this basic stock. Indeed, one species is described by Fennah (1969) from New Caledonia, and also Synave (1956) mentions an undetermined female from Upemba national park (Zaire) in Africa. Even if such a distribution appears odd, these data indicate a broader distribution than only the Seychelles area. All others genera seems endemic to their island as on La Réunion, *Meenocixius* which clearly looks different from any other Cixiid genera.

But of course, at the supraspecific level, endemism is a difficult task to establish because phylogenetic studies are lacking and genus recognition is taxonomist dependent. In La Reunion, the Cixiid genera *Eumyndus* and *Borbonomyndus* for instance are rather close genera (but not necessarily sister taxa), and should have been considered congeneric by others, while they are well defined by their respective autapomorphies.

This is true also for Madagascar, and further collections and taxonomic revisions of the Cixiid fauna will probably increase the number of endemic genera, as on La Réunion. The species *Achaemenes andringitensis* Synave, 1965, is one example as this species clearly does not belong to *Achaemenes* and will have to be reassigned to a new genus. On the other hand, *Typhlobrixia* for instance, which seems to differ from *Brixia* only in a few modifications attributable to its subterranean way of life (Synave, 1953; 1956), could be included into the *Brixia* clade even if it is well separated from this genus by its wing venation (in particular the absence of the common stem M+Sc+R).

In other words, comparison of not necessarily comparable generic taxa (only phylogenetically sister taxa should be) is meaningless and the only report on the Mascarenes Cixiids should recognise that the distribution of the cosmopolitan genera decreases with the distance from Madagascar and should not focus on the endemic genera. Dispersal appears to be a major factor determining the origin of the faunal diversity of these recent islands. However, the presence of some derived endemic genera, like *Meenocixius*, provide evidence of subsequent speciation. But without phylogenetic data, most of these conclusion remain speculative.

At the specific level, the analysis of distribution patterns paradoxically reveals a higher specific diversity on Mauritius, which is more distant and much more strongly influenced by man (Williams & Williams, 1988). This island has almost three times as many species as La Réunion but half as many genera (Table 2). Moreover, Mauritius seems more homogenous in terms of habitat diversity than La Réunion, as it is smaller (1865 km^2 versus 2512 km^2) and has a lower altitude (826 m versus 3069 m). This does not favour speciation as a factor of the origin of the faunal diversity.

Of course, the older age of Mauritius (8 million years) compared to La Réunion (3 million years) may account for the higher species diversity. But how does one explain the absence of any endemic genus? One answer would be

TABLE. 2. Distribution and numbers of species (sp) of Cixiid genera (gr) on Madagascar and the Mascarenes Islands, with their geological age, in parenthesis.

Genera	Madagascar	Mascarenes			Distribution
		La Réunion [3 MY]	Mauritius [8 MY]	Rodrigues [1,5 MY]	
Brixia	**36**	**4+1**	**27**	**3**	Madagascar
Achaemenes	**12**	**1**	**3**	**-**	Africa
Oliarus	**6**	**2**	**3**	**-**	Palaearctic, Oriental, and Australian regions
		(species probably non congeneric)			
Aselgeoides	**2**	**1**	**-**	**-**	Seychelles, Africa, New Caledonia
Typhlobrixia	**1**	**-**	**-**	**-**	Madagascar, endemic
Eumyndus	**3**	**-**	**-**	**-**	Madagascar, endemic
E. perinetensis	**1**	**-**	**-**	**-**	Madagascar, endemic
Nesomyndus	**1**	**-**	**-**	**-**	Madagascar, endemic
Borbonomyndus	**-**	**2**	**-**	**-**	La Réunion, endemic
Meenocixius	**-**	**2**	**-**	**-**	La Réunion, endemic
Achaebana	**-**	**-**	**-**	**1**	Rodrigues, endemic
Total	8 gr / 62 sp	6 gr / 13 sp	3 gr / 33 sp	2 gr / 4 sp	
Notes	Nb genera underestimed	1 *Brixia* sp. in prep.			

that the origin of the Cixiid fauna of Mauritius is due to multiple and repetitive successful dispersal events, most probably evolving without speciation. Conversely, on La Réunion, several dispersal events were followed by evolution of new species groups and the establishment of endemic genera. A phylogeny of these taxa would test this hypothesis. It is interesting to note that in the last case, a consequence of the successful speciation would render all the dispersing Malagasian genera paraphyletic.

In conclusion, among the Fulgoromorpha the Cixiid family on La Réunion is the richest in endemic species (Attié, 1999). Indeed 11 of the 13 species are endemic (85%), and moreover they are associated with native plants. Likewise, on Mauritius 31 of the 33 species are endemic (94%) and found on native vegetation (Williams, 1975a). However, the species diversity on the two islands has probably a different origin. Compared to La Réunion, the greater distance from Mauritius to Madagascar is balanced by its older geological age, and it has probably received and retained more colonists. Furthermore, the lower degree of generic endemism on Mauritius might reflect reduced speciation because it is apparently more homogenous.

New studies are now needed to show how much of this biodiversity can be explained in terms of dispersal followed by island speciation, as can be assumed for the endemic genera of La Reunion Moreover, the overall significance of colonization events has to be evaluated, particularly on Mauritius. Finally more attention should be paid to the influence of host plant diversity, which obviously had a great impact on the speciation of these sap sucking insects.

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